

Depth Imaging

Outline

- **Time vs Depth**
- **Principles**
- **Latest Technology**
- **Projects**

Time vs Depth Imaging

- **Although time imaging is data in time and depth imaging is data in depth that's not what's important**
- **What really matters is that time migration doesn't handle velocity variations well while depth migration does**

Time Imaging

- Processing *in Time*
- Imaging *in Time*
- Interpretation *in Time*
- Under certain assumptions, the time-image represents the sub-surface
- Final **time-to-depth conversion** yields a geological model

Depth Imaging vs Time Imaging

- **Vertical Positioning:** Events are in their true vertical position.
- **Lateral Positioning:** Events are placed in their correct lateral position
- **Resolution:** Higher resolution because depth imaging does not rely on hyperbolic stack as time migration does.
- **Verification:** The accuracy of the velocity model can be verified based on the flatness of the imaged gathers.

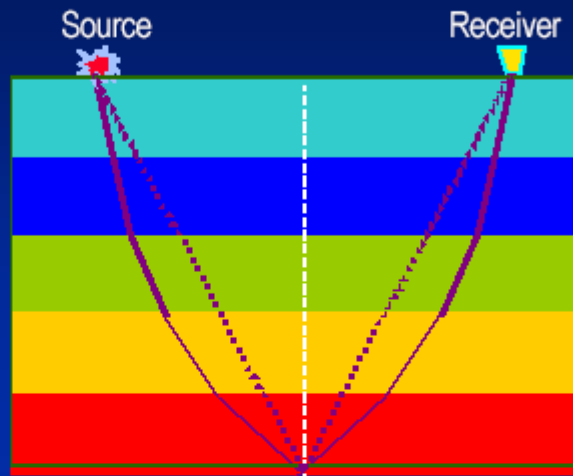
Depth Imaging

- **Processing-Imaging-Interpretation-Geological Model building** *in Depth*
- **A more rigorous imaging method**
- **Seismic Imaging verifies a geological model**
- **Its success depends on the accuracy of the Velocity macro-model**

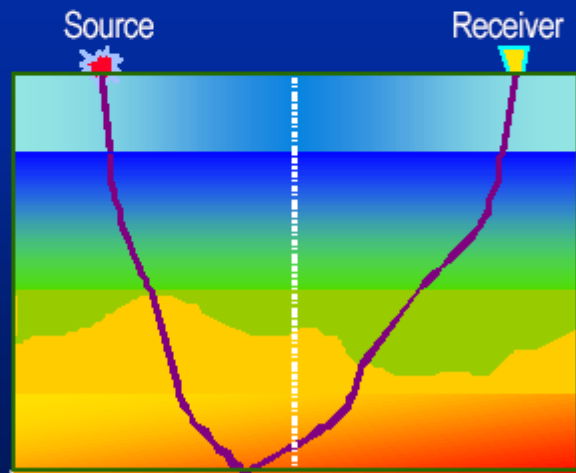
Time vs Depth Imaging

- **Lateral velocity variations violate conventional time assumptions**
 - **cause non-hyperbolic moveout**
 - **bend the rays**
- **Improved imaging using depth migration**
 - **Correct vertical positioning**
 - **Correct lateral positioning**
 - **Improved resolution**
 - **Allows velocity and depth**

Prestack Kirchhoff Time Vs. Depth Imaging - *semantics*



Time Migration : program retrieves the velocity profile at the CMP and either computes the travel time via the DSR equation (straight ray) or ray traces through this local 1D model (curved ray) but no lateral velocity changes are comprehended , the ray path is always symmetric about a zero offset trace



Depth Migration: a full travel time table is build externally. The travel time generator program comprehends velocity changes vertically and laterally (as full 3D model). The migration program retrieves the travel time from this table to move the sample. The ray path can be non symmetric



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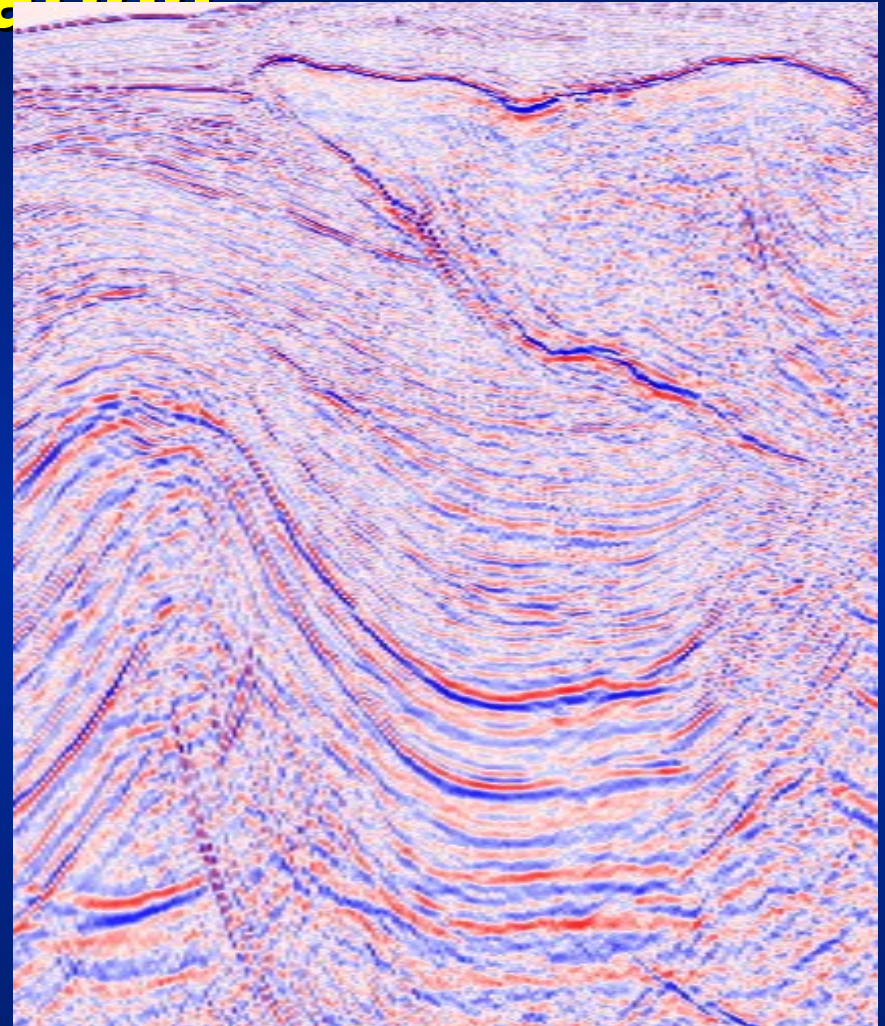
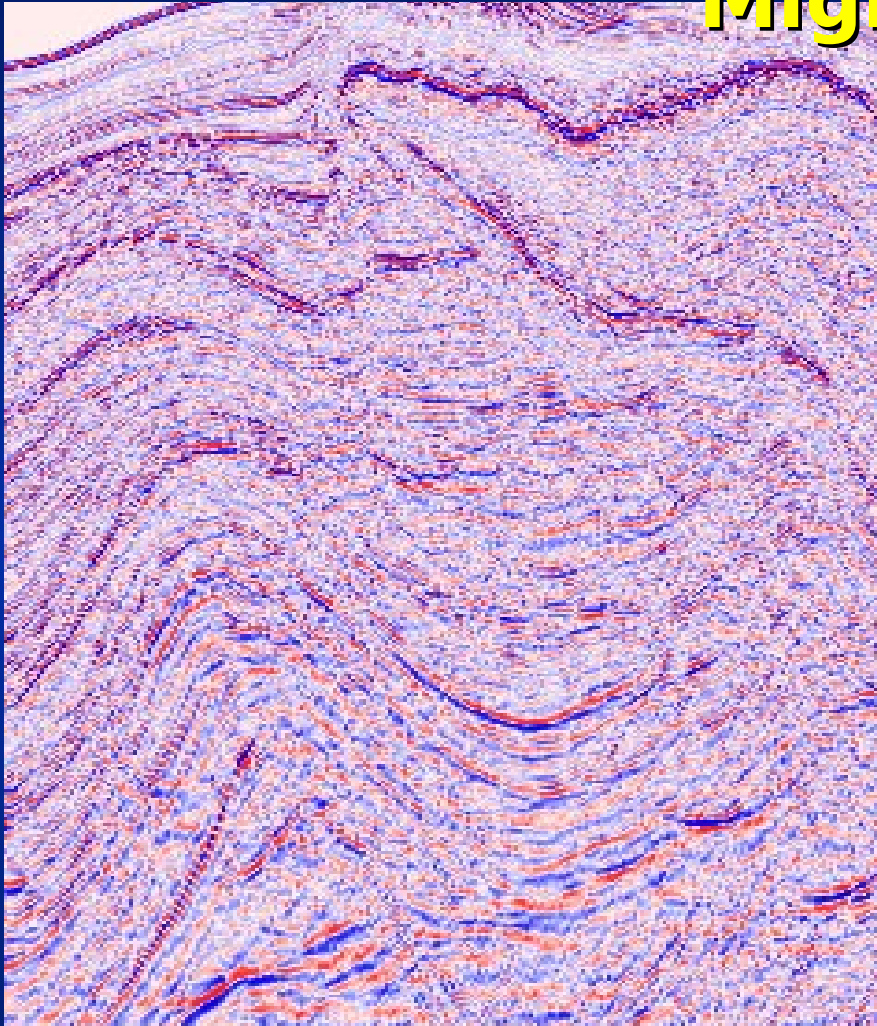
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DP3-DI; Basic concepts & principles - 3

Time Migration

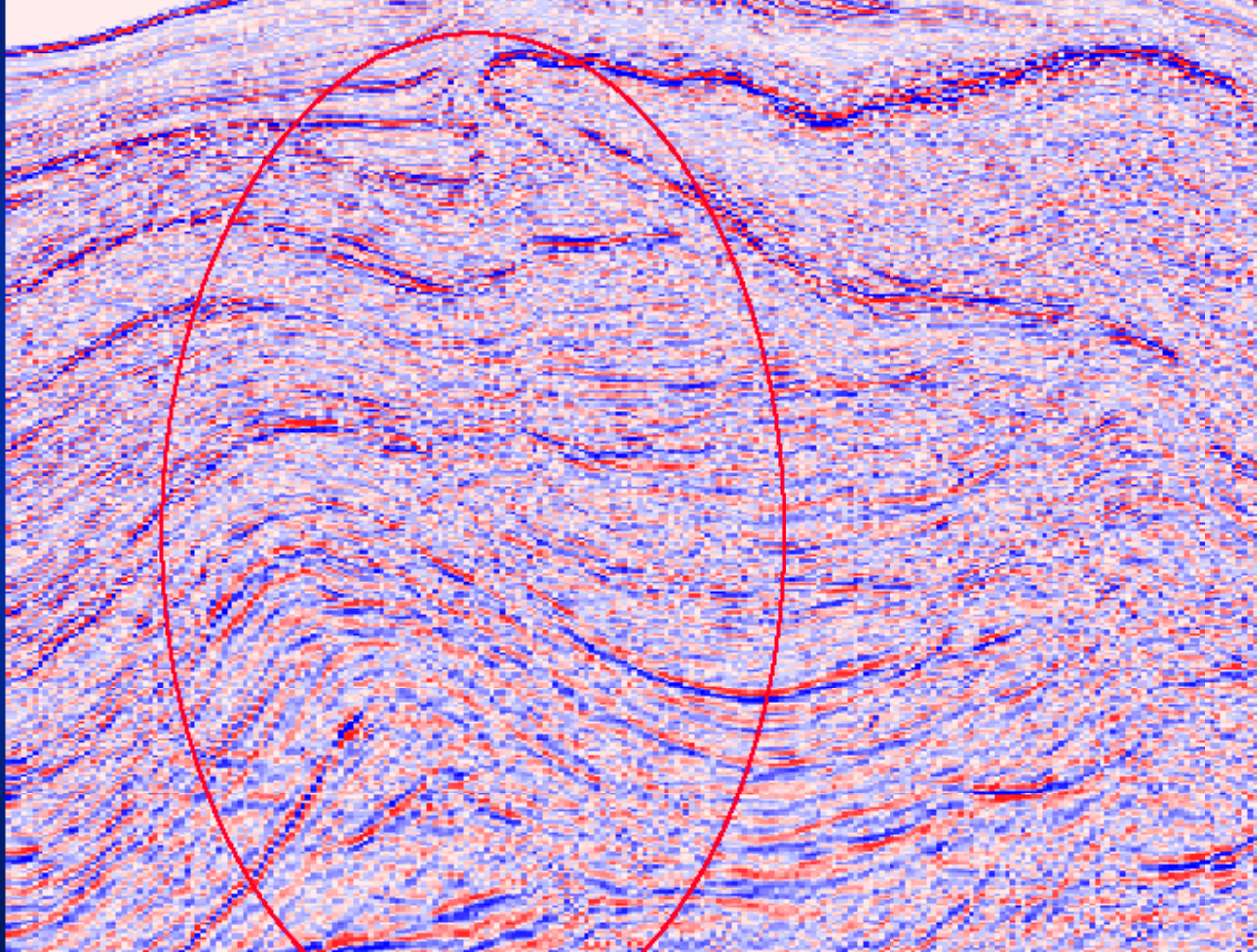
Migration

Depth

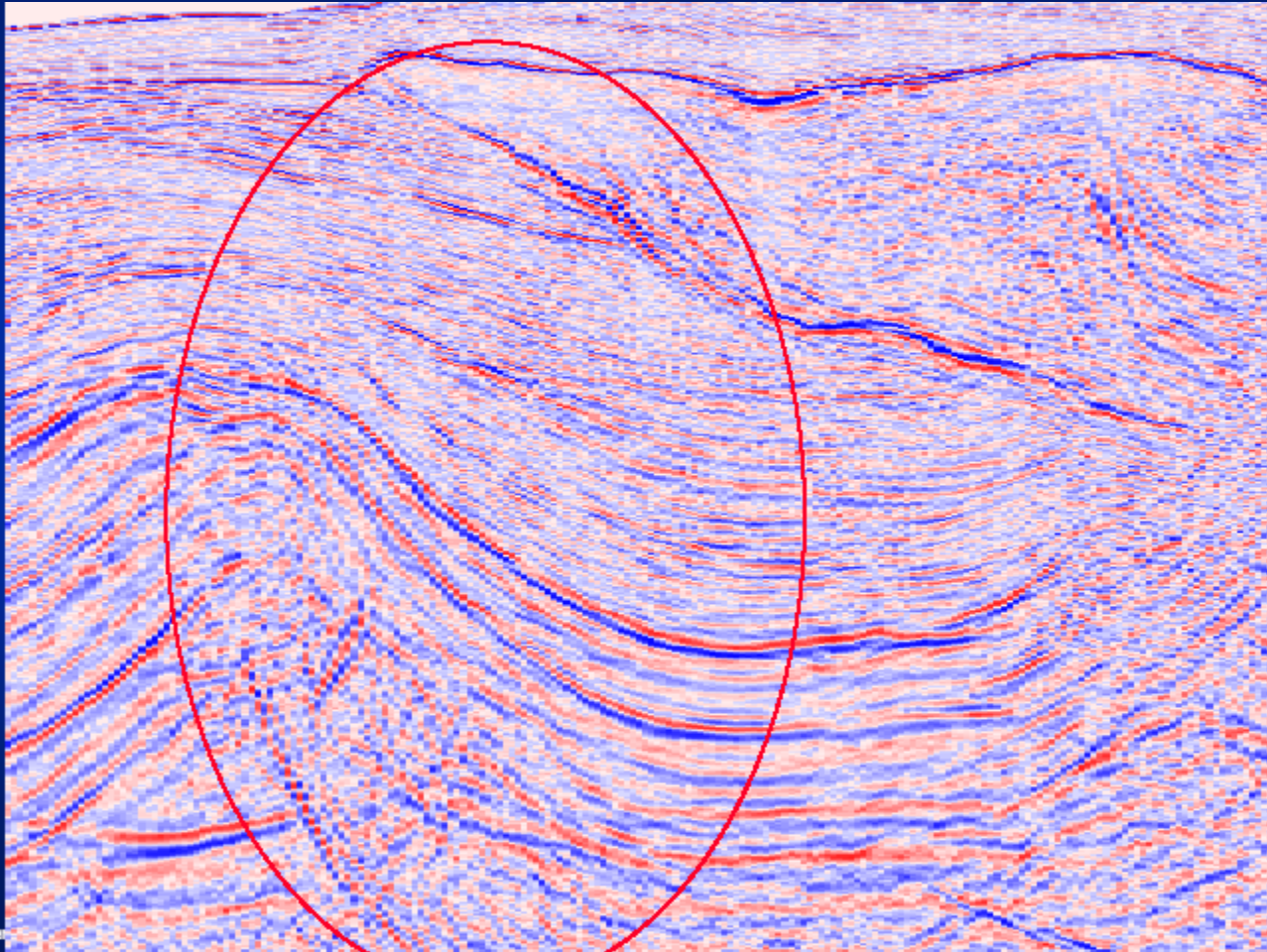


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Time Migration



Depth Migration

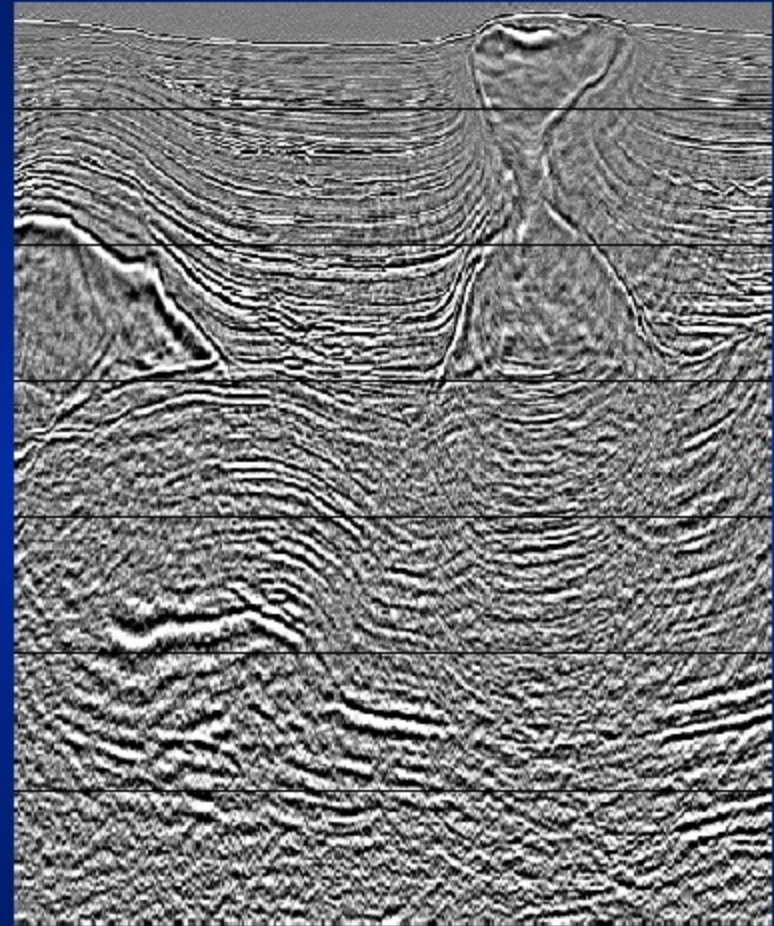
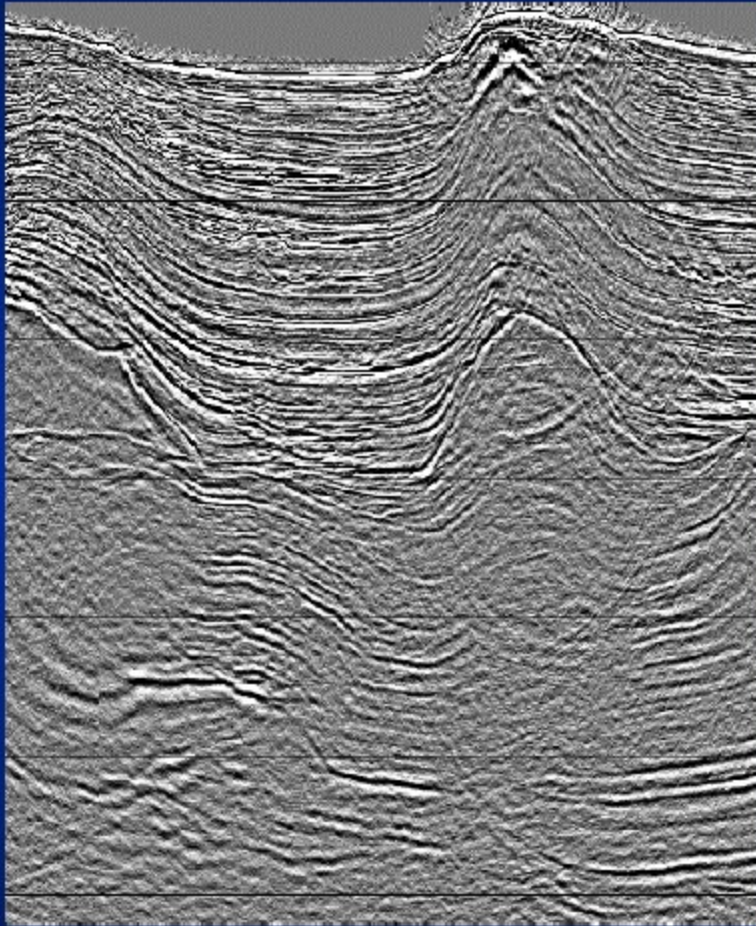


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Geological settings where Depth Imaging is needed

- **High velocity lithologies (chalk, salt, basalt)**
- **Faulted structures**
- **Gas clouds**
- **Shallow channels**
- **Overthrust areas**
- **Laterally varying velocities**

Salt

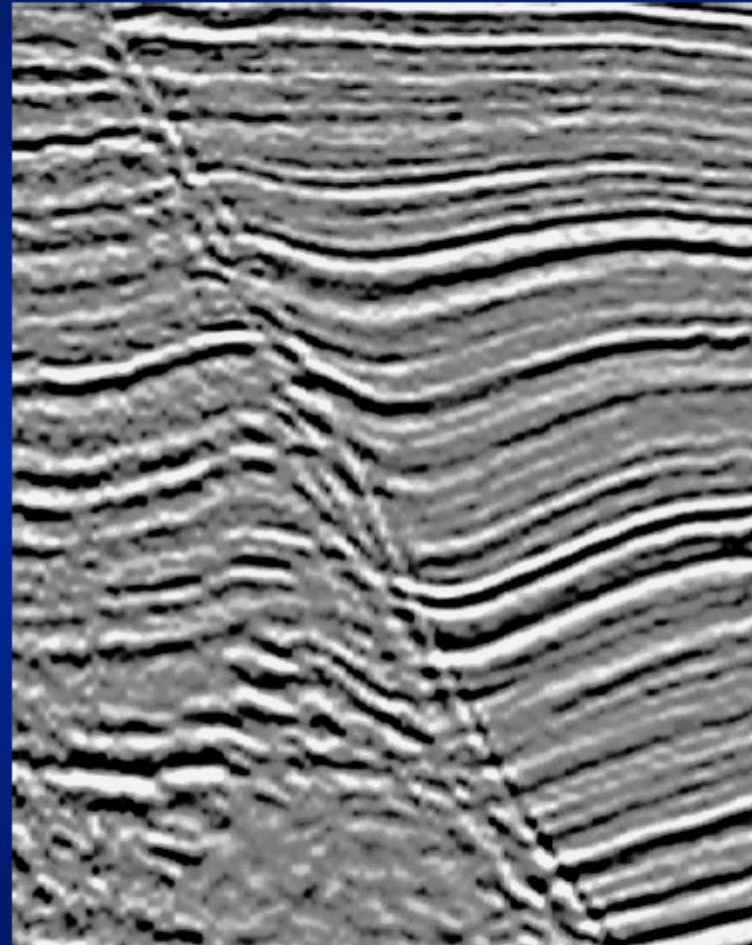
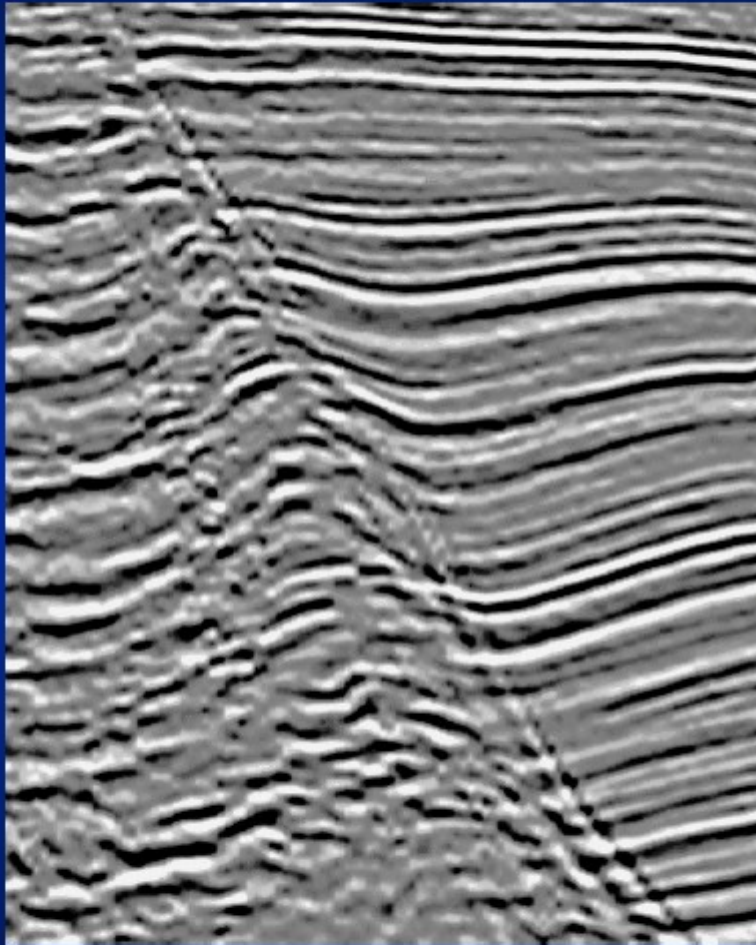


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Time Migration

Depth Migration

Faulting

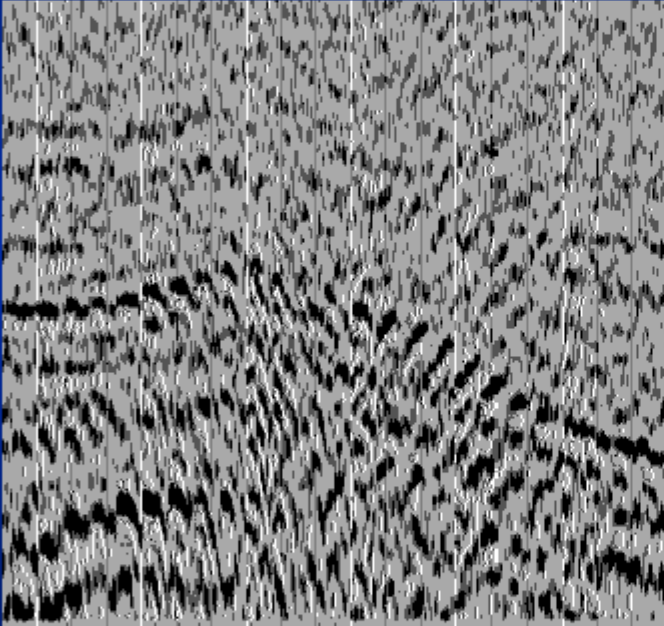


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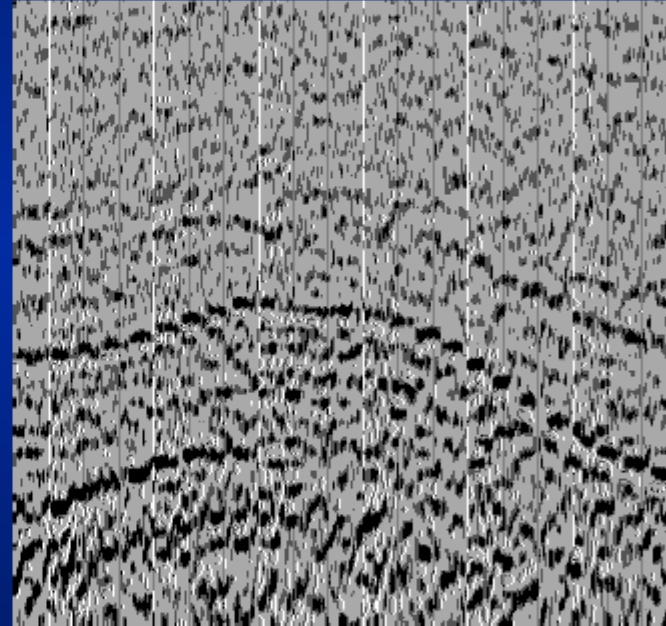
Time Migration

Depth Migration

Gas Clouds



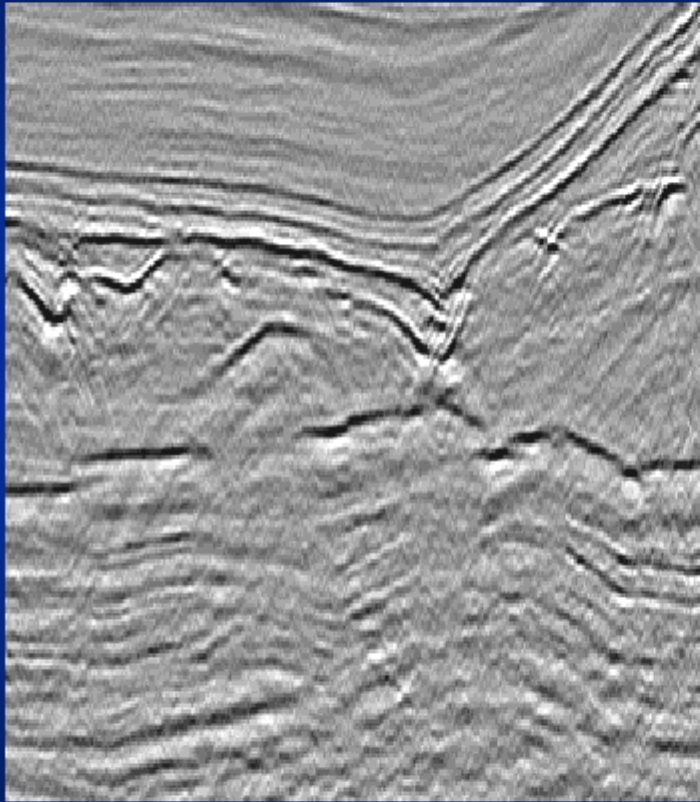
Before velocity modelling



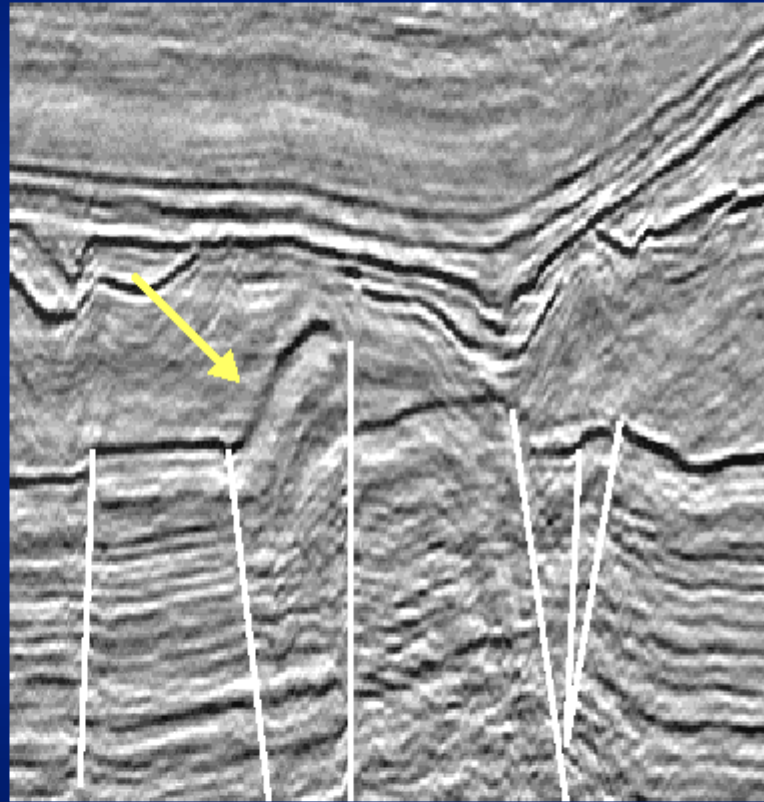
After velocity modelling

Rotliegend Pop-up Structures

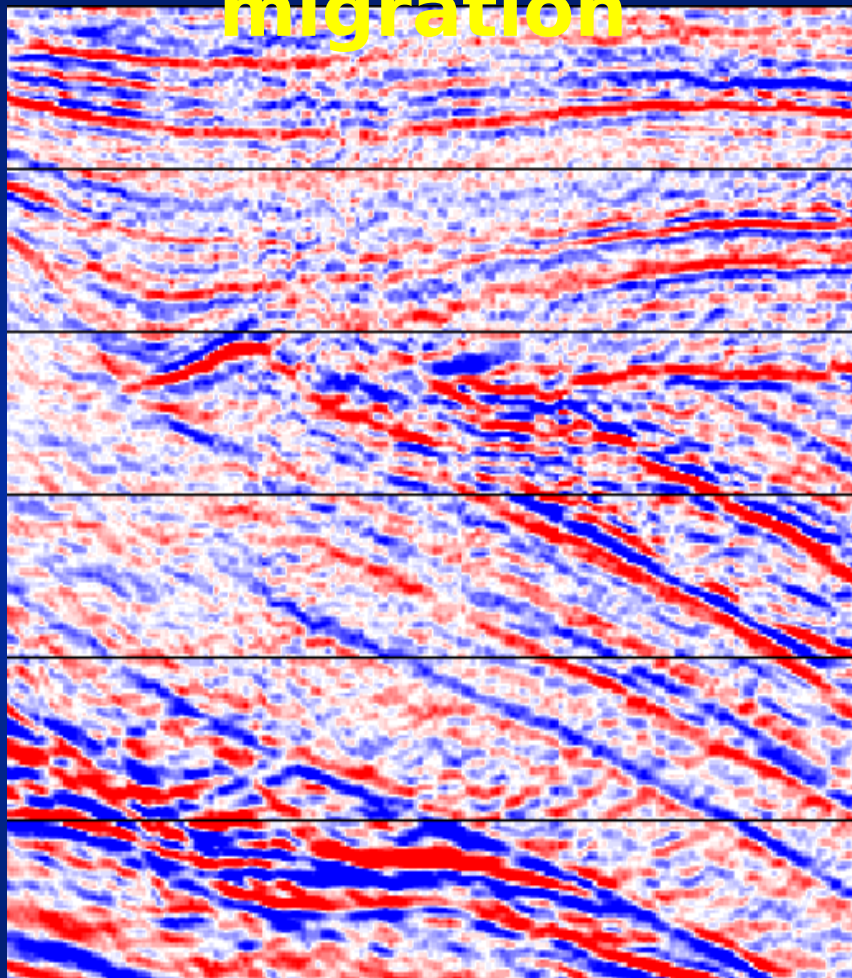
Time Migration



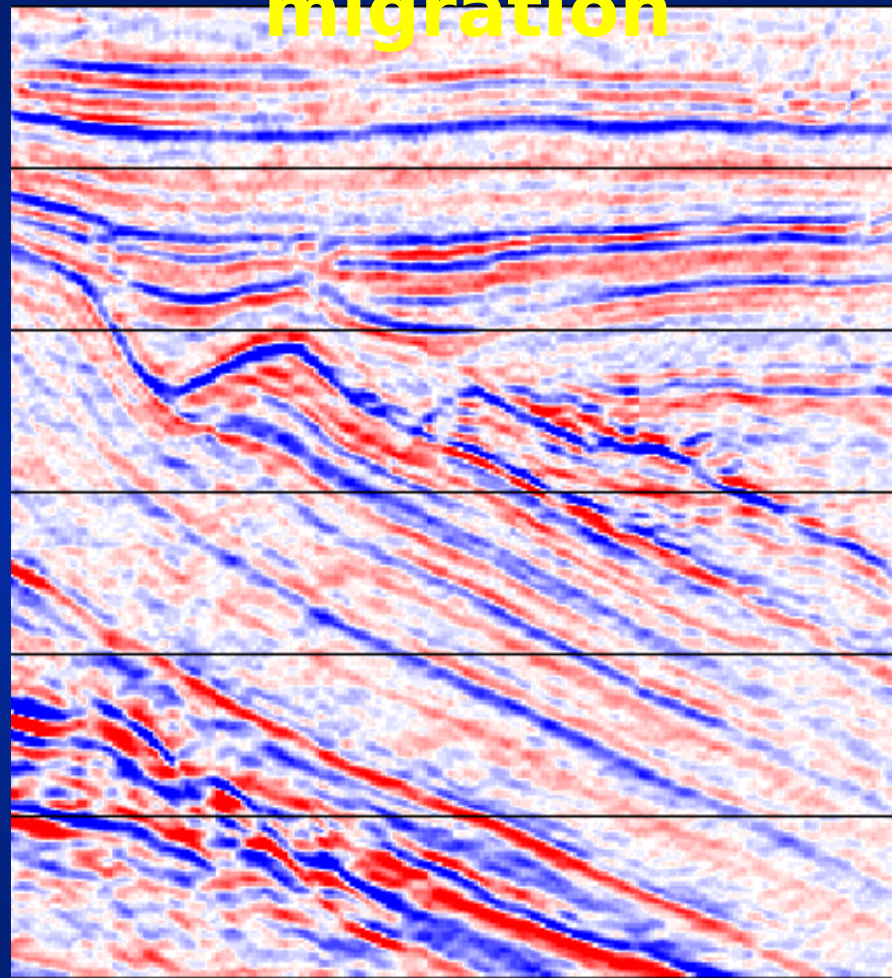
Depth Migration



Post-stack time migration



Pre-stack depth migration



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Reasons for not using depth migration

- It requires huge computational effort
 - expensive
- Building accurate models is hugely time consuming & sometimes problematic
 - The result is only as good as the model used for migration
 - expensive
- Data handling and management
 - Iterative process requiring access to the same dataset for long periods of time

Outline

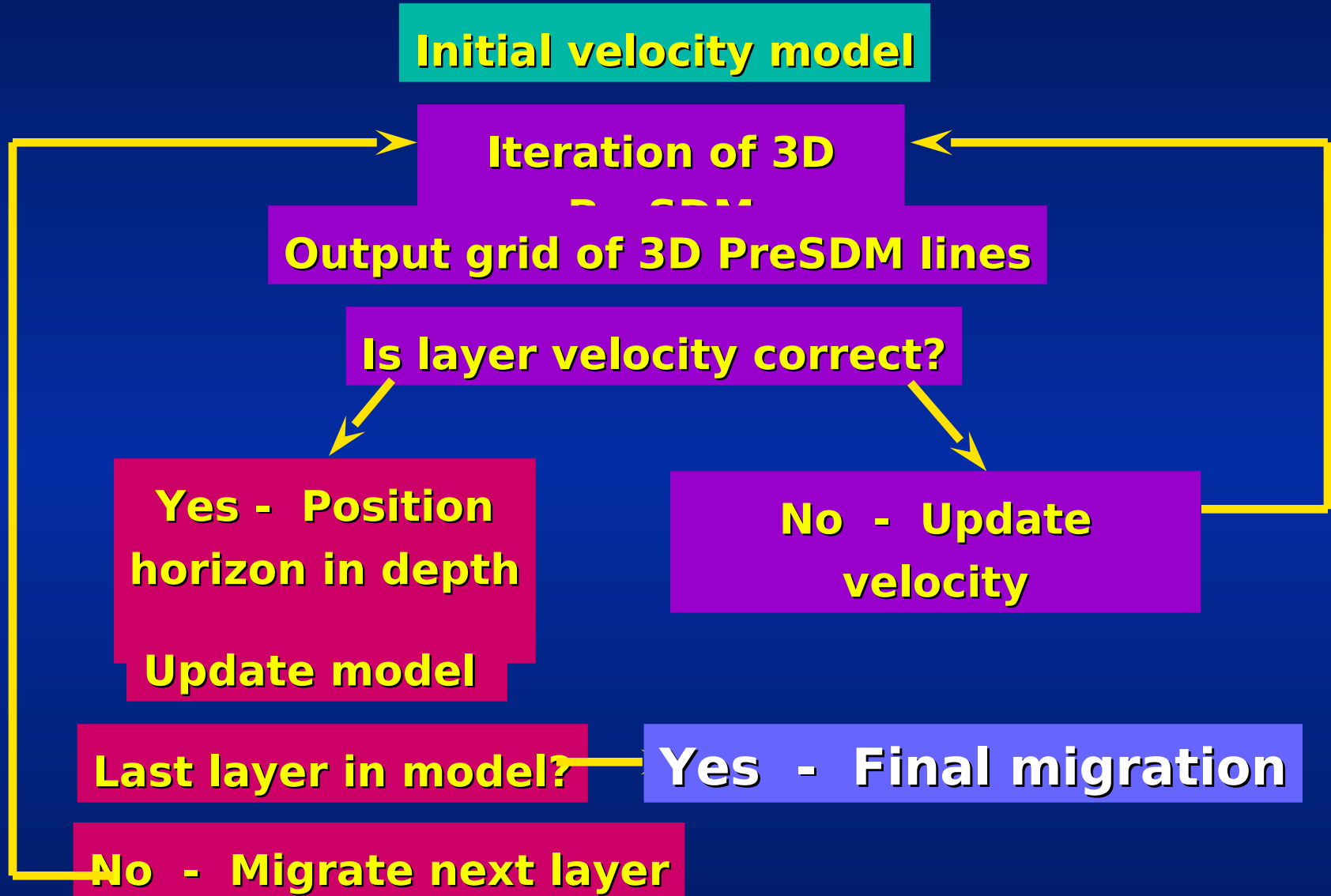
- **Time vs Depth**
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- **Projects**

Tomography

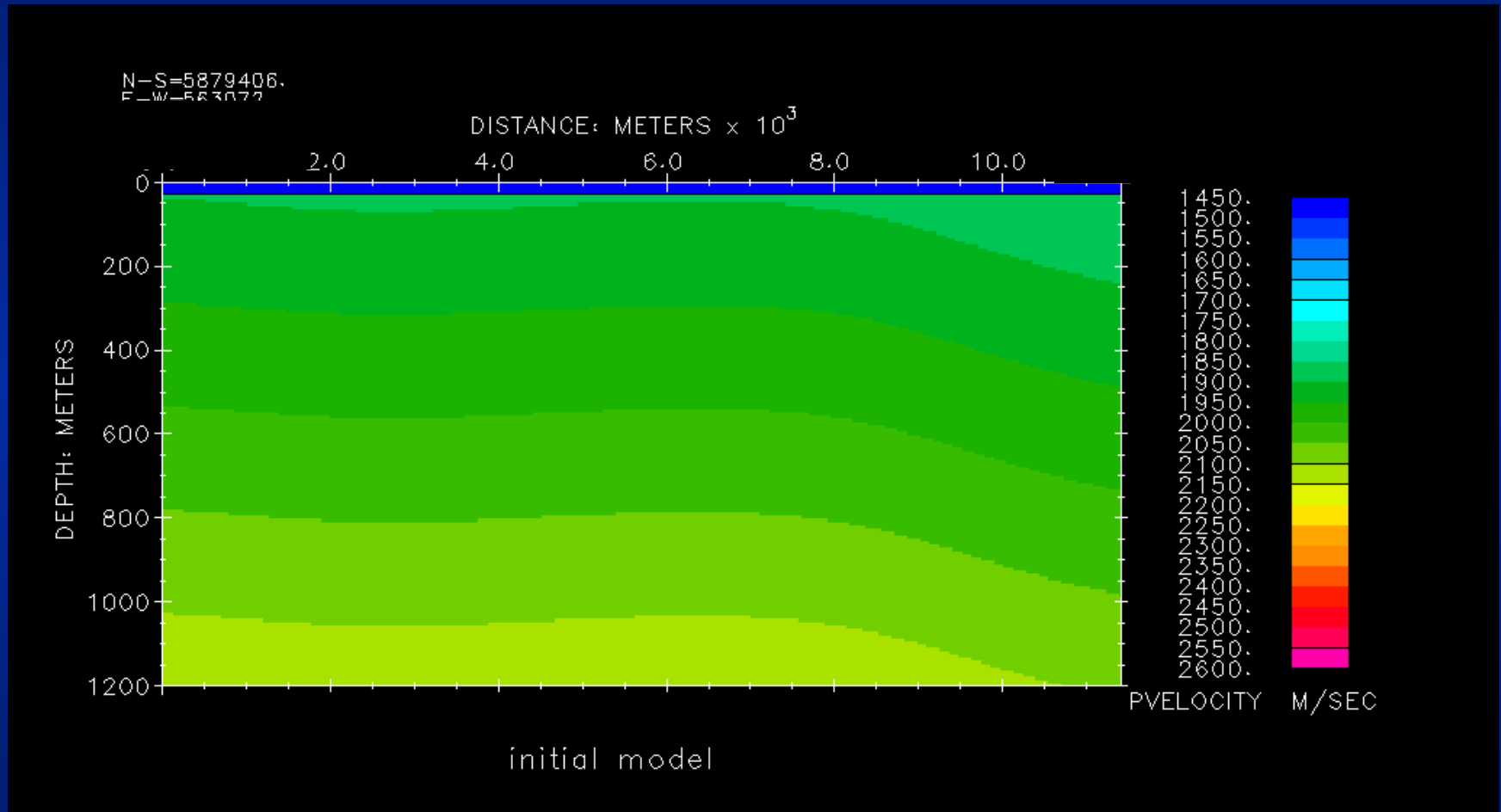
- **Tomography is a type of inverse problem**
- **It finds the interior distribution of values inside an object from projections measured outside of it**
- **Measurements are first made of some energy that has propagated through a medium**
- **The received character of this energy is then used to infer the values of the medium through which it has propagated**

• **Seismic tomography uses travel-time**

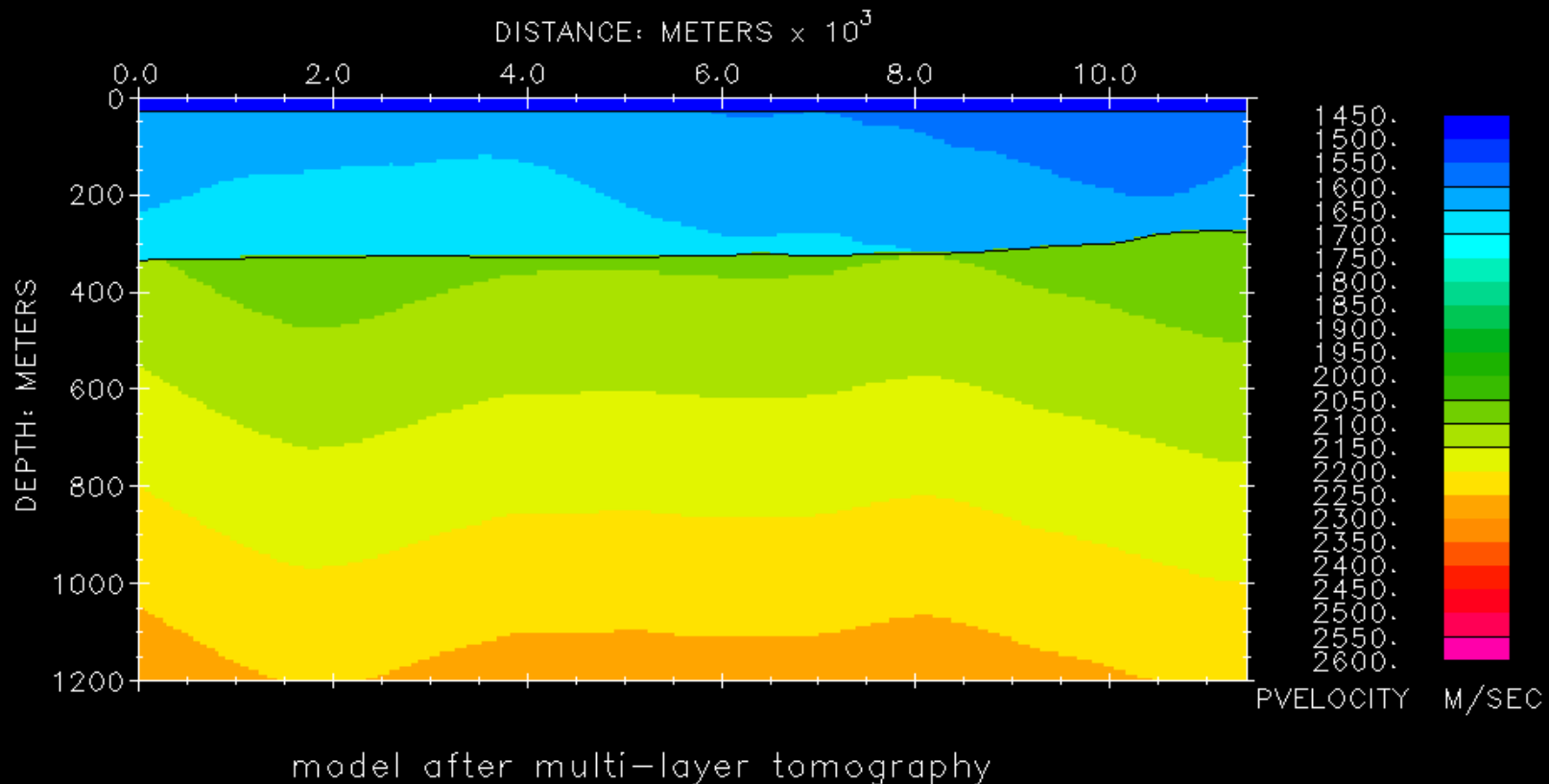
Model building flow



Initial velocity model



Velocity model after multi-layer tomography



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Anisotropy

Isotropy means that whatever the direction of propagation of our wavefront the velocity is the same

Anisotropy is where the velocity of the rock is different depending on which direction you are travelling through it.

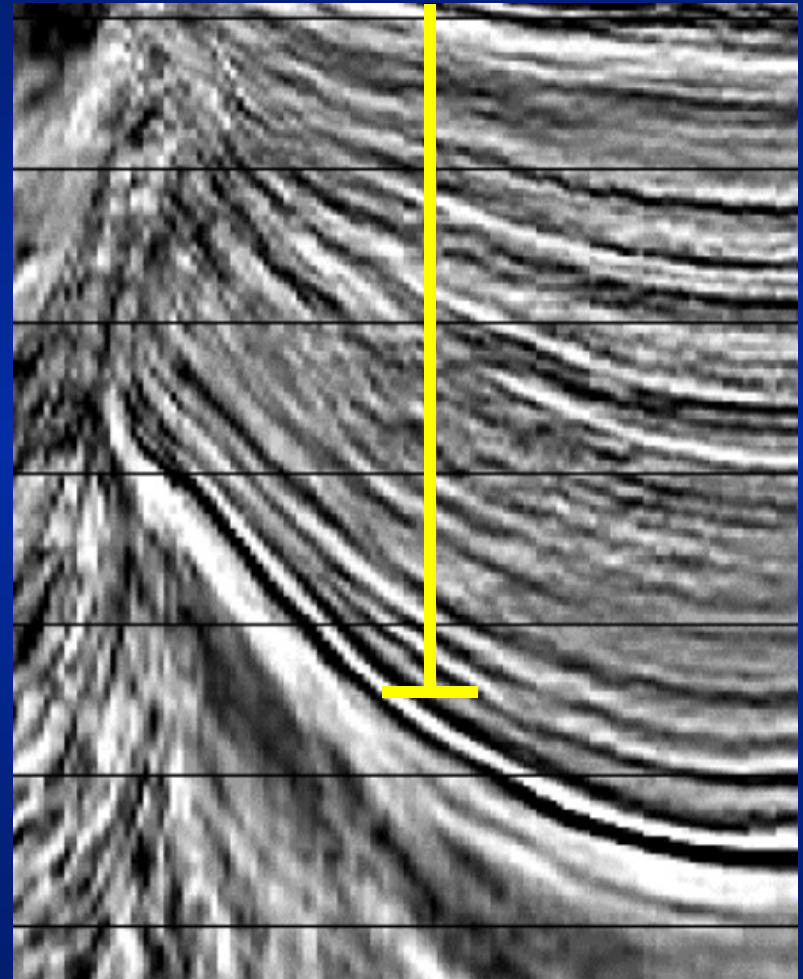
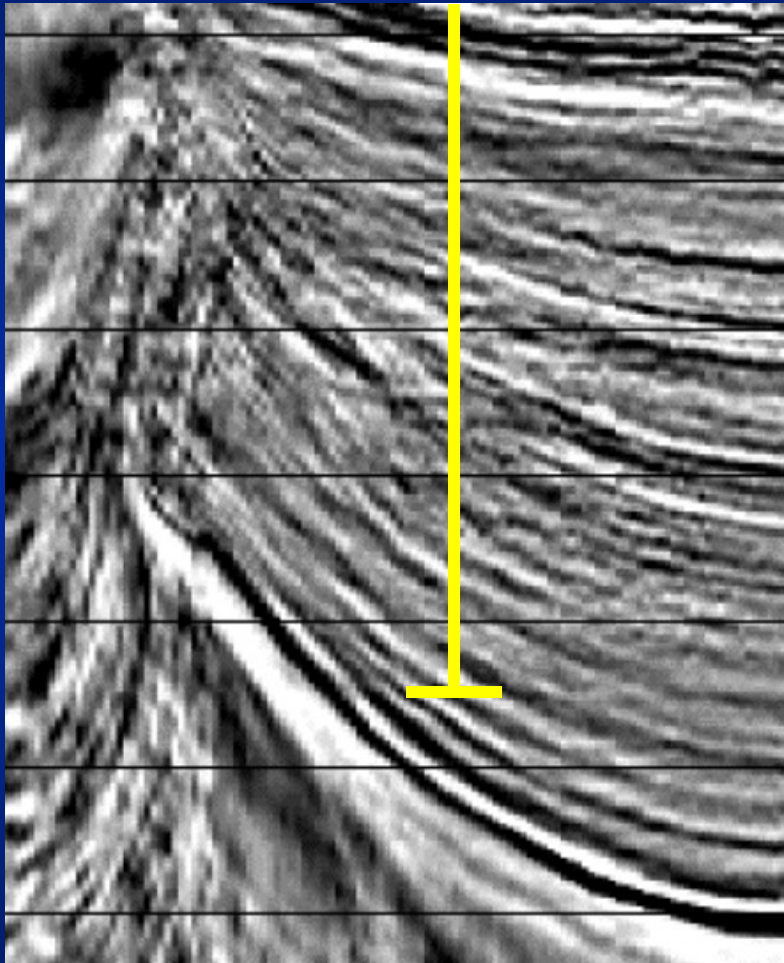
Anisotropy is probably most obvious in shale layers, where the velocity can vary by 10% or more, depending on the

Anisotropy

Causes of anisotropy

- **layering**
beds thinner than the seismic wavelength
with differing velocities
- **fracturing**
- **intrinsic**
crystals exhibit different behaviour in
different directions

Isotropic model Anisotropic model



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Latest Technology

- **Layer Based and Grid Based tomographies for automatic velocity updating**
- **Incorporating anisotropy**
- **Depth Imaging 4C data**
- **Wavefield extrapolation migration**
- **Depth migrations on pc clusters**

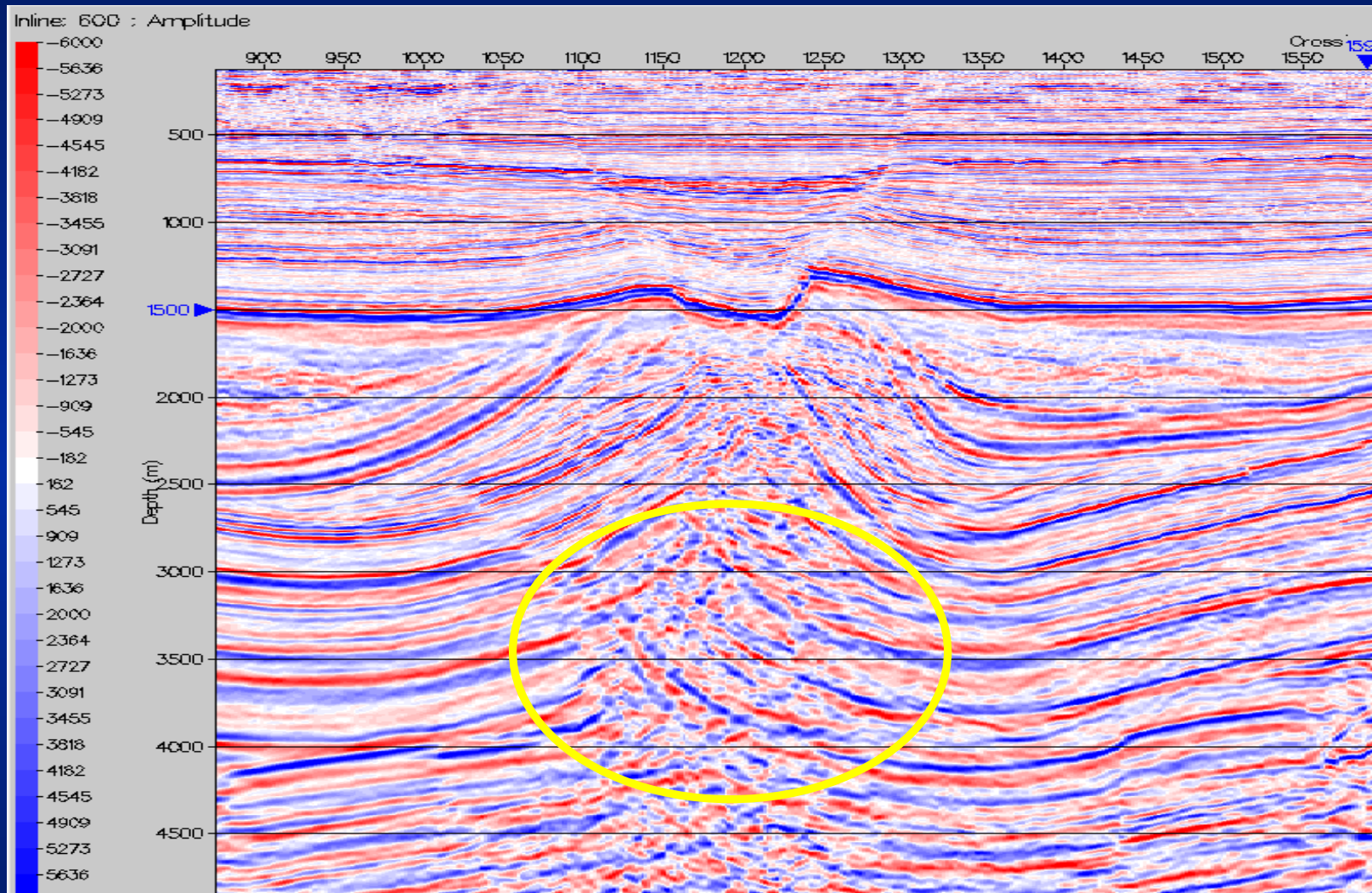
Multi-component depth imaging

- **3D pre-stack depth migration of 4C wide azimuth data**
 - **Simultaneously update of P and S velocity models using 3D tomography**
 - **Incorporate anisotropy to tie equivalent PP and PS events in depth**
- **End product - well-imaged PZ and PS datasets which tie each other and the wells in depth**

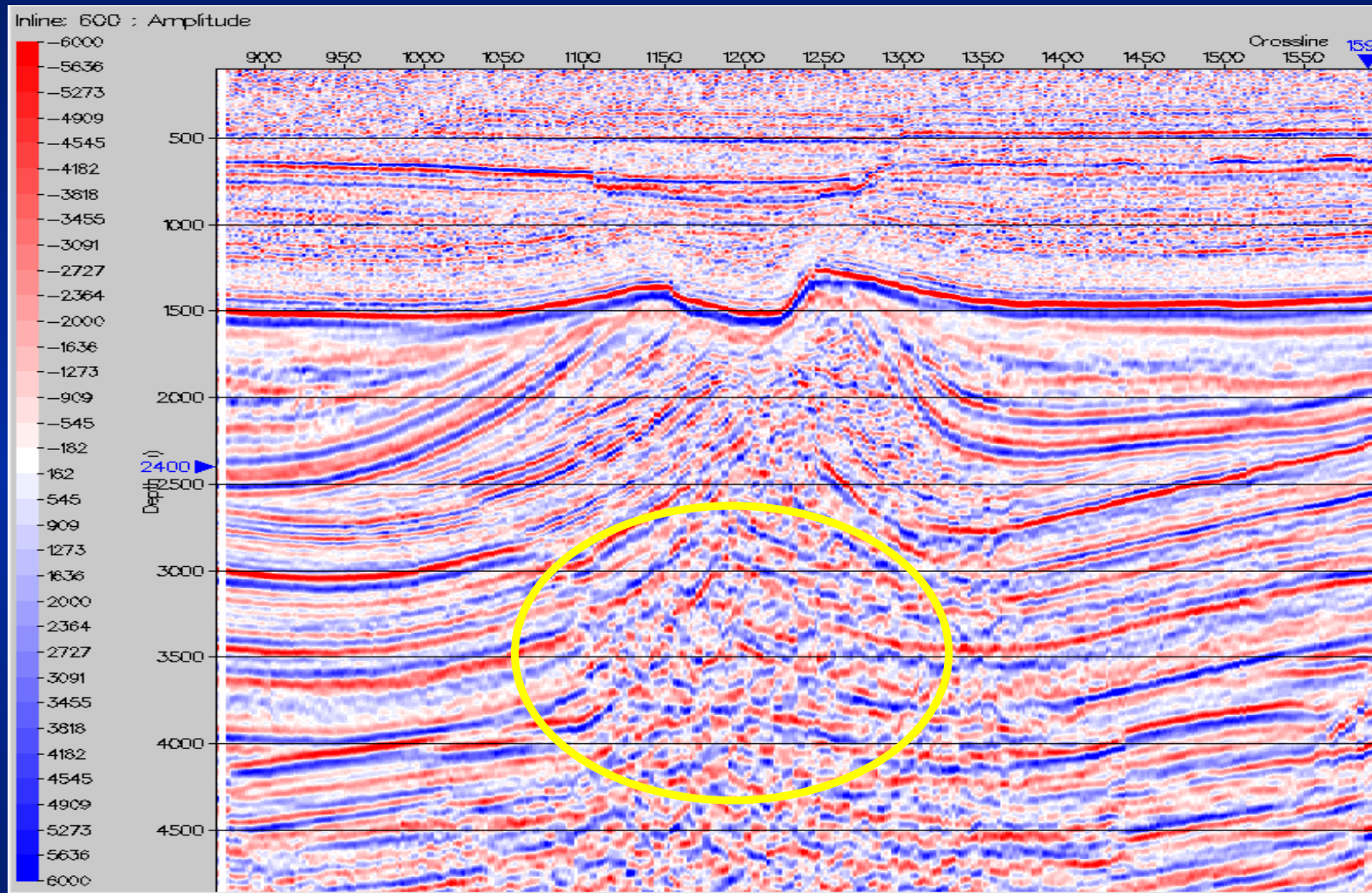
WEM Migration

- **WEM is new but proven to give improved sub-basalt imaging**
 - **Handles multi-pathing easily and thus handles more complex structure and allows simpler amplitude treatment**
 - **Image all volume (thus costly)**
 - **Obtaining good dip response is expensive**
 - **Doesn't readily produce pre-stack data**
 - **Difficult to produce cost effective iterative model building scheme**

Kirchhoff inl600



WEM inl600



Depth Imaging Projects

- **Sub-salt (GoM, S and C N Sea, Offshore Gabon and Angola)**
- **Faulted structures (N Sea, offshore Namibia)**
- **Imaging below gas clouds (N Sea, Caspian)**
- **High resolution imaging through gas (Adriatic)**
- **Sub-basalt (W. Britain)**
- **Overthrust areas (S America)**

Further information

- Can be found at the following
Intouch number 3796560